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REMOTELY PILOTED VEHICLE (RPV) AUTOMATIC RECOVERY SYSTEM.(U)
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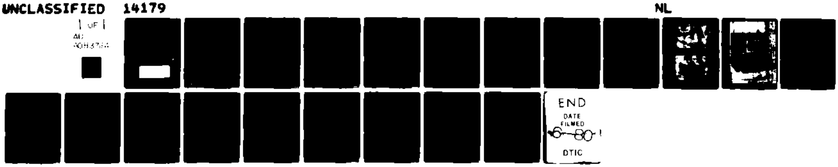

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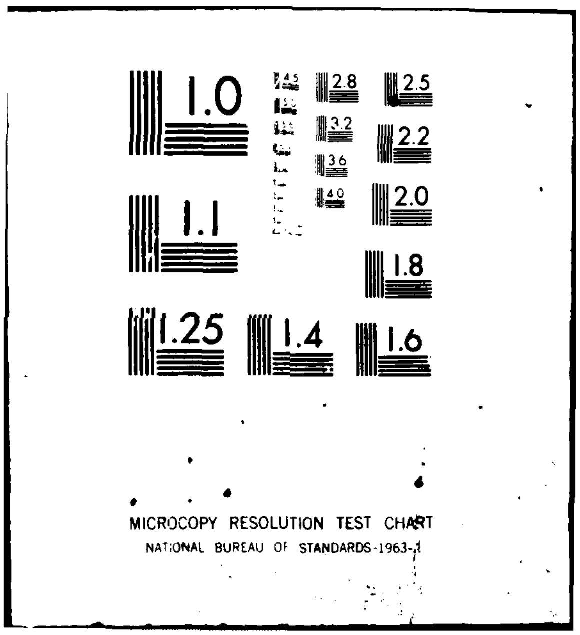
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DEVELOPMENTAL SCIENCES INC

15757 EAST VALLEY BOULEVARD
P. O. BOX 1264
CITY OF INDUSTRY, CALIF. 91749
(213) 330-6865

RPV AUTOMATIC RECOVERY SYSTEM

CONTRACT NO. DAAJ02-77-C-0050

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AUTOMATIC RECOVERY FLIGHT TESTS

FINAL REPORT

April 18, 1979

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A mini - RPV was tested utilizing up link and down link between a co-scanning ground station and an on-board autopilot to direct the RPV on its final approach to recovery.

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Submitted by

DEVELOPMENTAL SCIENCES, INC.
15757 E. Valley Blvd.
P. O. Box 1264
City of Industry, California 91749

April 18, 1979

14179-FR

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FOREWARD

This report describes the work accomplished by Developmental Sciences, Incorporated, City of Industry, California, in the design, development, and flight testing of an All Weather RPV and Automatic Recovery System. The work was performed for the Applied Technology Laboratory, United States Army Research and Technology Laboratories, (AVRADCOM) Ft. Eusits, Virginia, under Contract DAAJ02-77-C-0050 as modified. The program was performed during the period from April 1978 thru March 1979.

The United States Army Program Monitor was Mr. Thomas Allardice of the Military Operations Technology Division, Ft. Eustis, Virginia. His assistance and cooperation were appreciated.

1. INTRODUCTION

This report describes the results of a series of flight test to demonstrate an Automatic All Weather Recovery System for mini-RPV's. A modified SKY-EYE was equipped with an autopilot and television camera and was automatically controlled to fly into the net recovery system designed and tested for the U.S. Army, under Contract No. DAAJ02-76-C-0039. SKY-EYE R-4C was also equipped with a backup parachute recovery system designed and tested under U.S. Army Contract No. DAAJ02-77-C-0050, Task II. DSI had substantial support from Lear Seigler Inc. Astronics Division (LSI) and also support from AIL Division of Cutler Hammer (AIL) and Tayburn Electronics.

1.1 Purpose of Test

The purpose of the tests was to demonstrate the feasability of and identification of the hardware required to accomplish an Automatic All Weather Capability Recovery of a mini-RPV into an existing net recovery system.

2. DESIGN ASPECTS

2.1 Design Criteria

The flight components required for operation of automatic flight were much greater than those components required for a hands-on radio controlled recovery. The required components were all packed into an existing airframe. Figure 1 describes the approximate location of the major components in the airframe.

Figure 2 is a three quarter front view which shows the mounting positions of the A.I.L. transmitting beacon, the heading gyro, the television camera and the 28 VDC battery pack.

Figure 3 is a three quarter rear view looking down into the fuselage, showing the mounting positions of the L.S.I. autopilot, the Tayburn TBD 400, the vertical gyro and the two gallon fuel tank.

2.2 Equipment Interface

The pilots console DSI 1GC-4D Figure 4, is the display unit designed to interface with and interpret the functions of the L.S.I. autopilot,

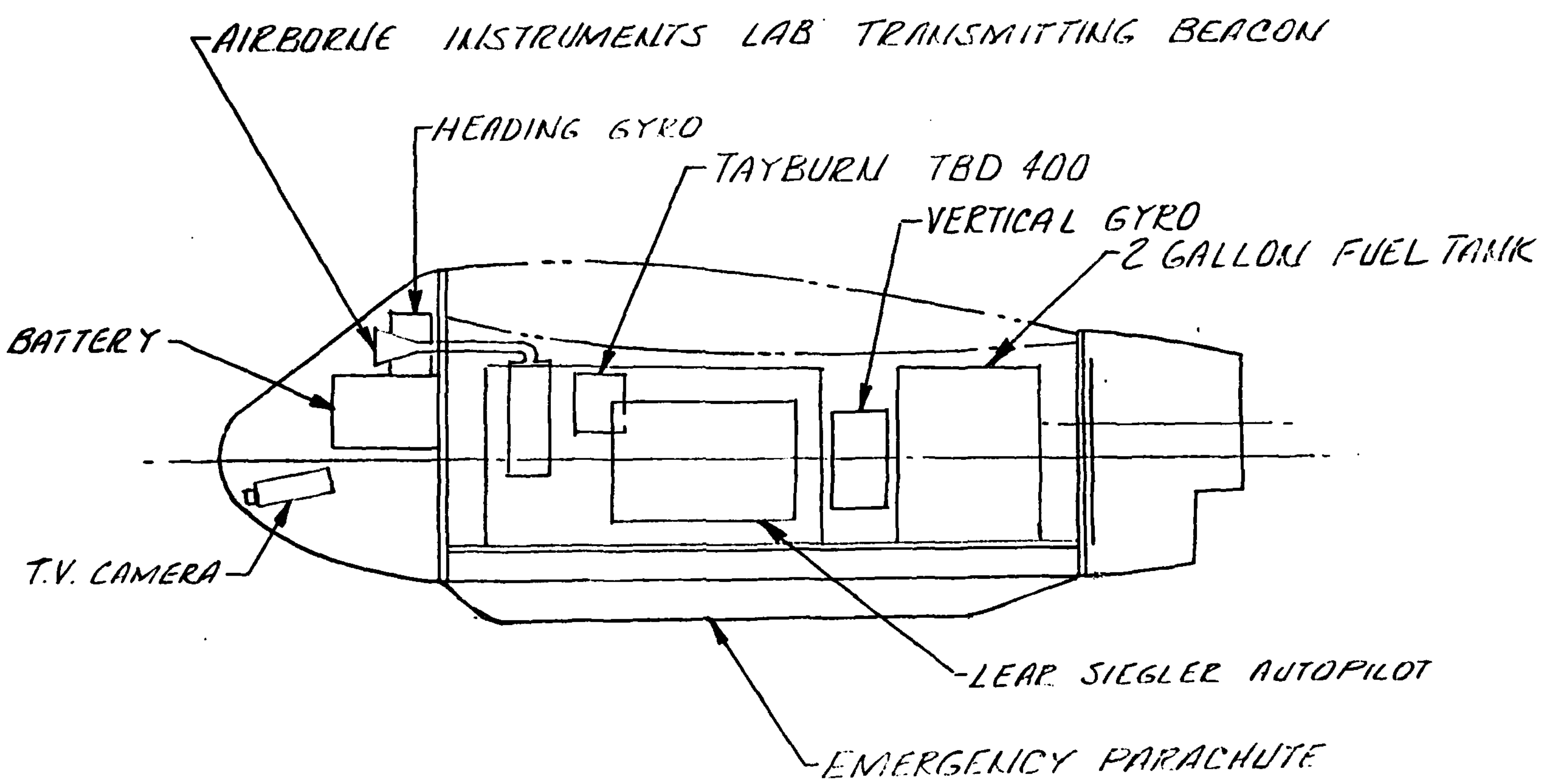


FIGURE 1 MAJOR COMPONENT LOCATIONS

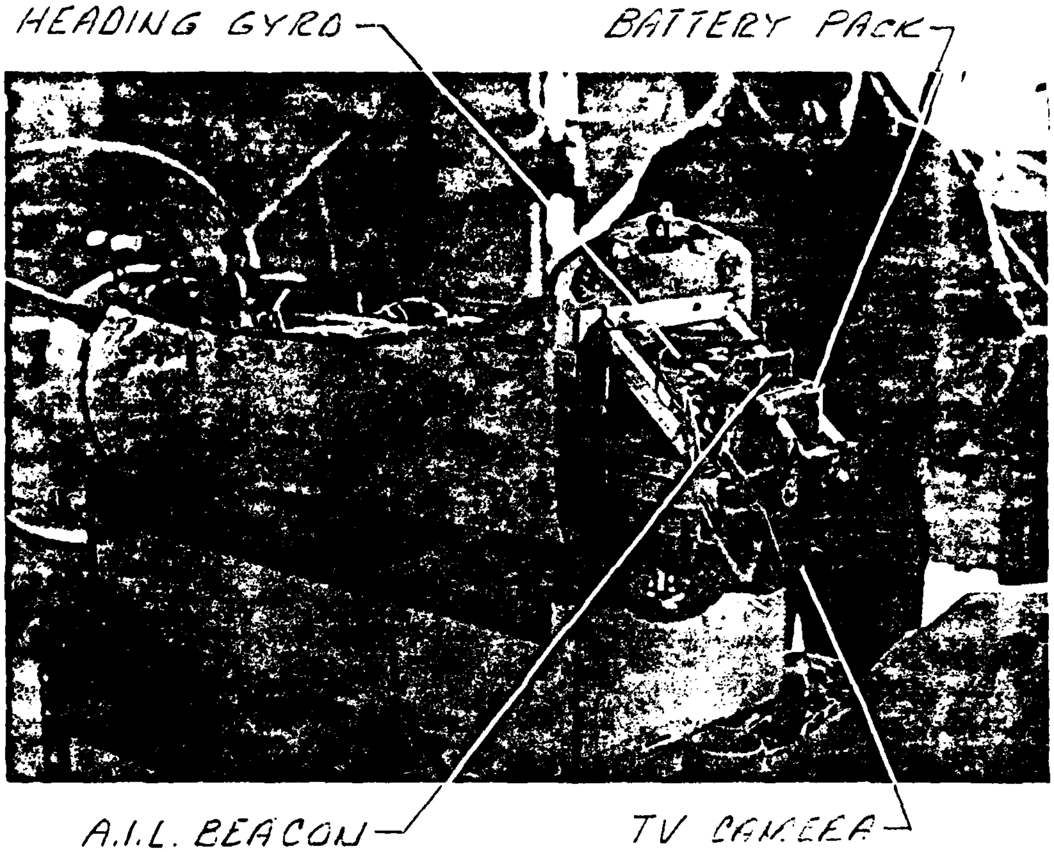


FIGURE 2

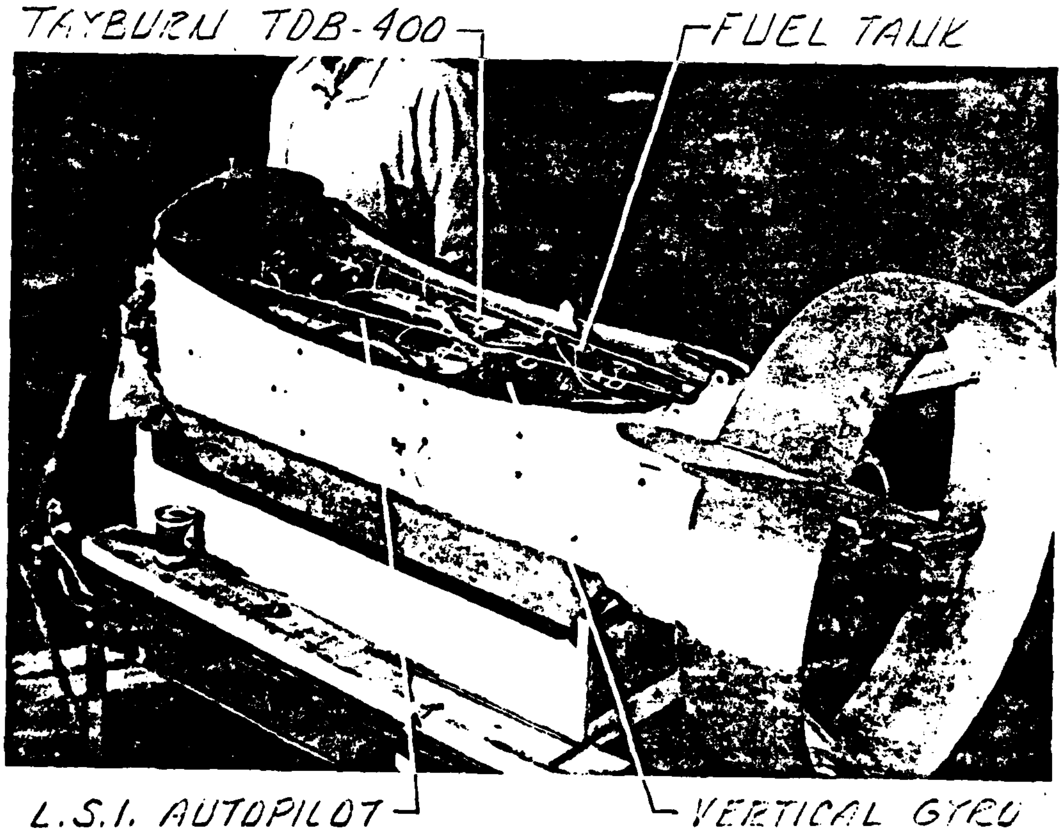
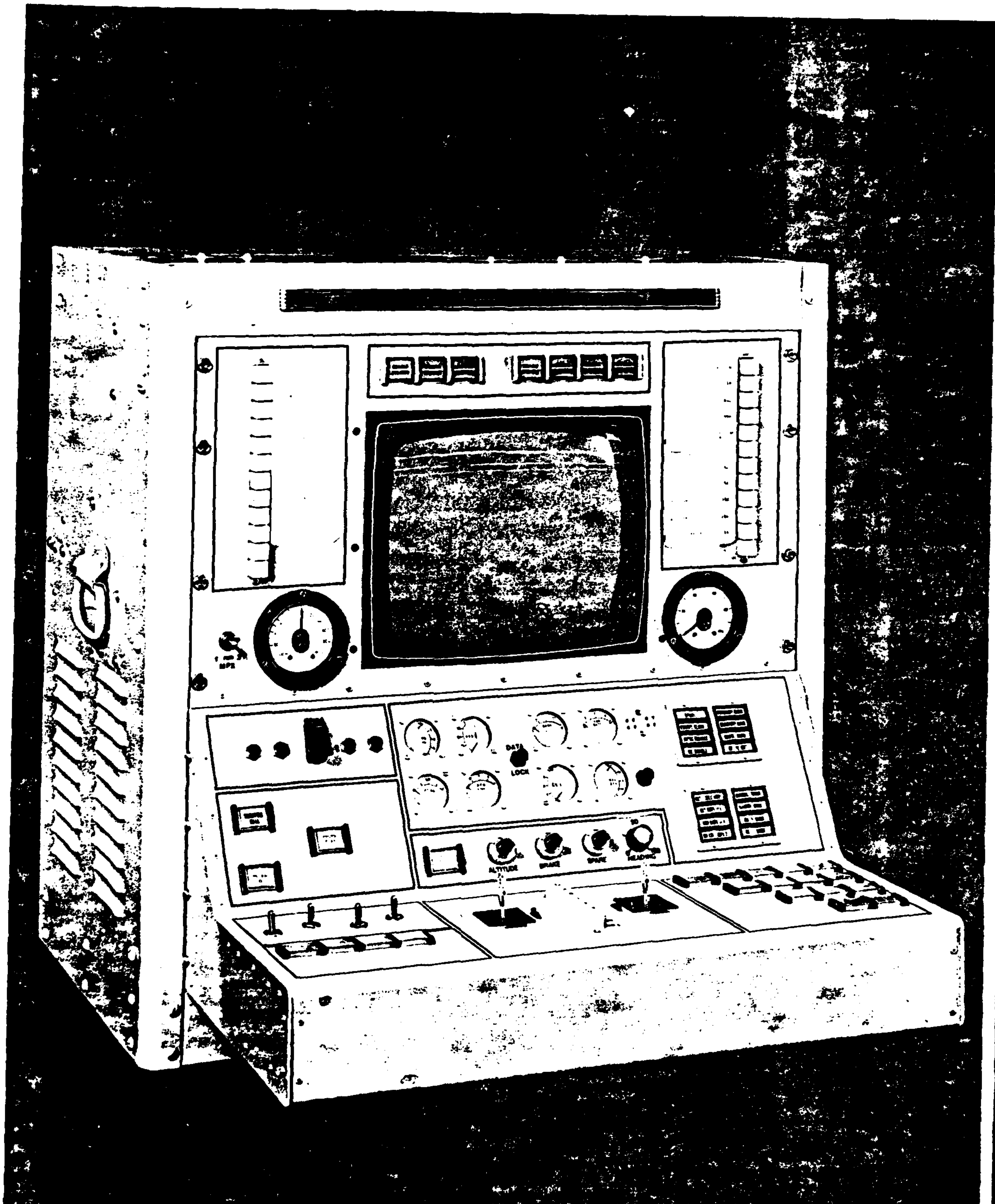


FIGURE 3



SKYEYE COMMAND CONSOLE

FIGURE (4)

the Tayburn encoder/decoder, the radio control override and the A.I.L. co-scanning terminal guidance and control of the SKY-EYE.

The pilots console permits the pilot to select the mode of operation, determine magnetic heading, altitude, engine rpm, rate of climb, airspeed, roll rate, yaw rate and glide slope.

2.3 Electronics

The command and telemetry systems incorporated in the SKY-EYE are improvements of previous designs proven and tested with the integration of the L.S.I. autopilot, the Tayburn encoder/decoder, and the A.I.L. terminal guidance system. An overall diagram of the command and telemetry system is shown in Figure 5.

The ground portion of the command link consists of a 16 channel pulse width encoder/exciter unit that is integrated into the pilots console. The output signal drives a 10.0 watt R.F. power amplifier and insures adequate signal strength for command function anywhere within a 10 mile range of the command base.

The airborne half of the command link is shown in Figure 6 and comprises a receiver, the Tayburn TBD 400 encoder/decoder and the Lear Siegler Inc. autopilot which provides proportional analog drive signals for the elevon and throttle servo-amplifiers. A discrete command is derived for engine kill.

The airborne portion of the telemetry system is shown in Figure 7 and consists of various transducers. A 16 channel multiplexer operating at 200 samples/sec, a 14.5 KHZ VCO sub carrier, and a 100 mc transmitter at 249.9 MHZ. The data channels monitor airspeed, rate of climb, altitude, left and right elevon position, RPM, magnetic heading, roll rate, yaw rate and glide slope.

The telemetry ground station (displayed in Figure 5) is comprised of an antenna, receiver, demultiplexer, event recorder, and strip chart recorder. The pilots console data display panel continually monitors the aircraft performance and attitudes.

An on board television camera provides the pilot with ground reference check points to aid in following a planned flight pattern during the flight test. The scenery picked up by the camera is then recorded

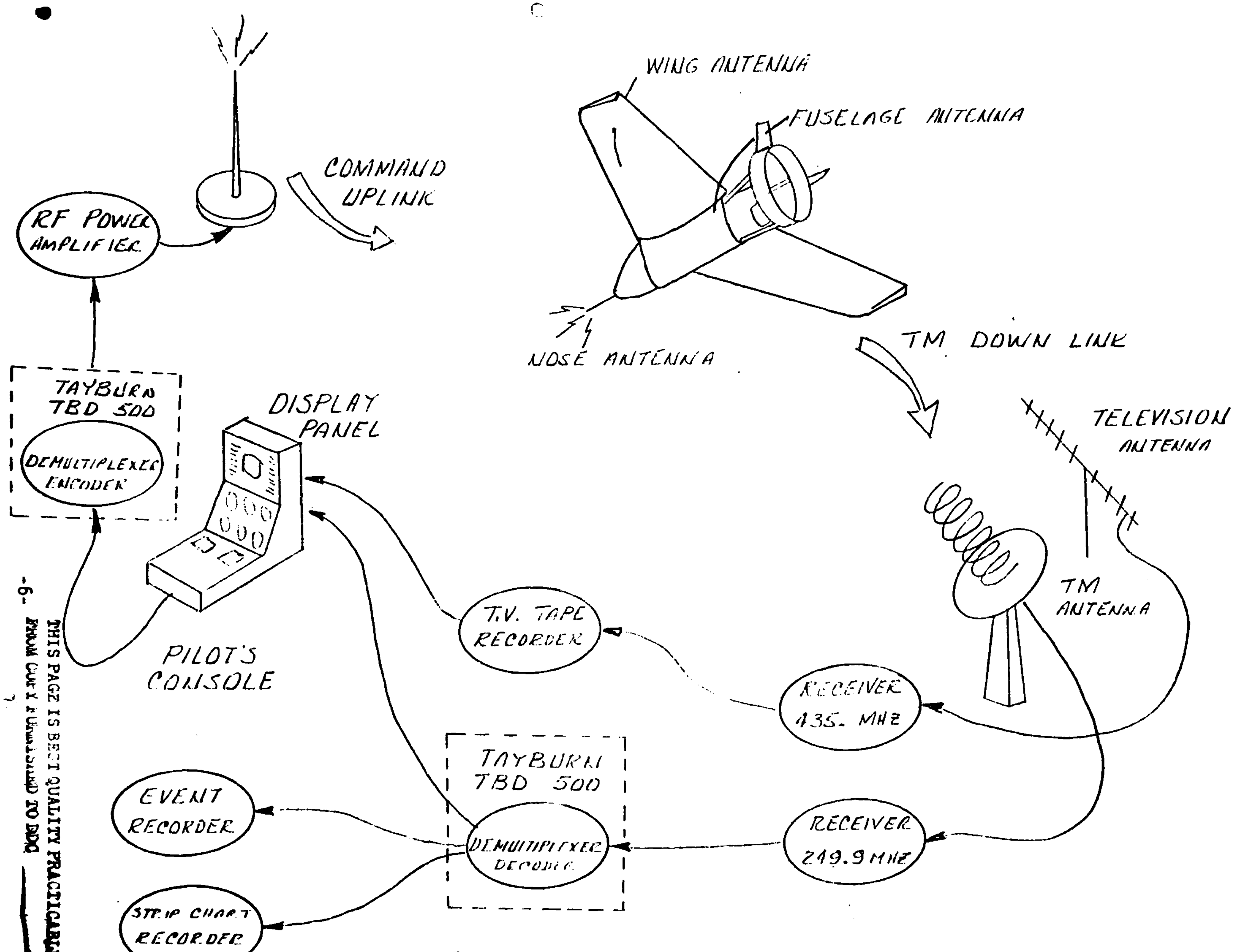


FIGURE 5 SKY-EYE ELECTRONICS

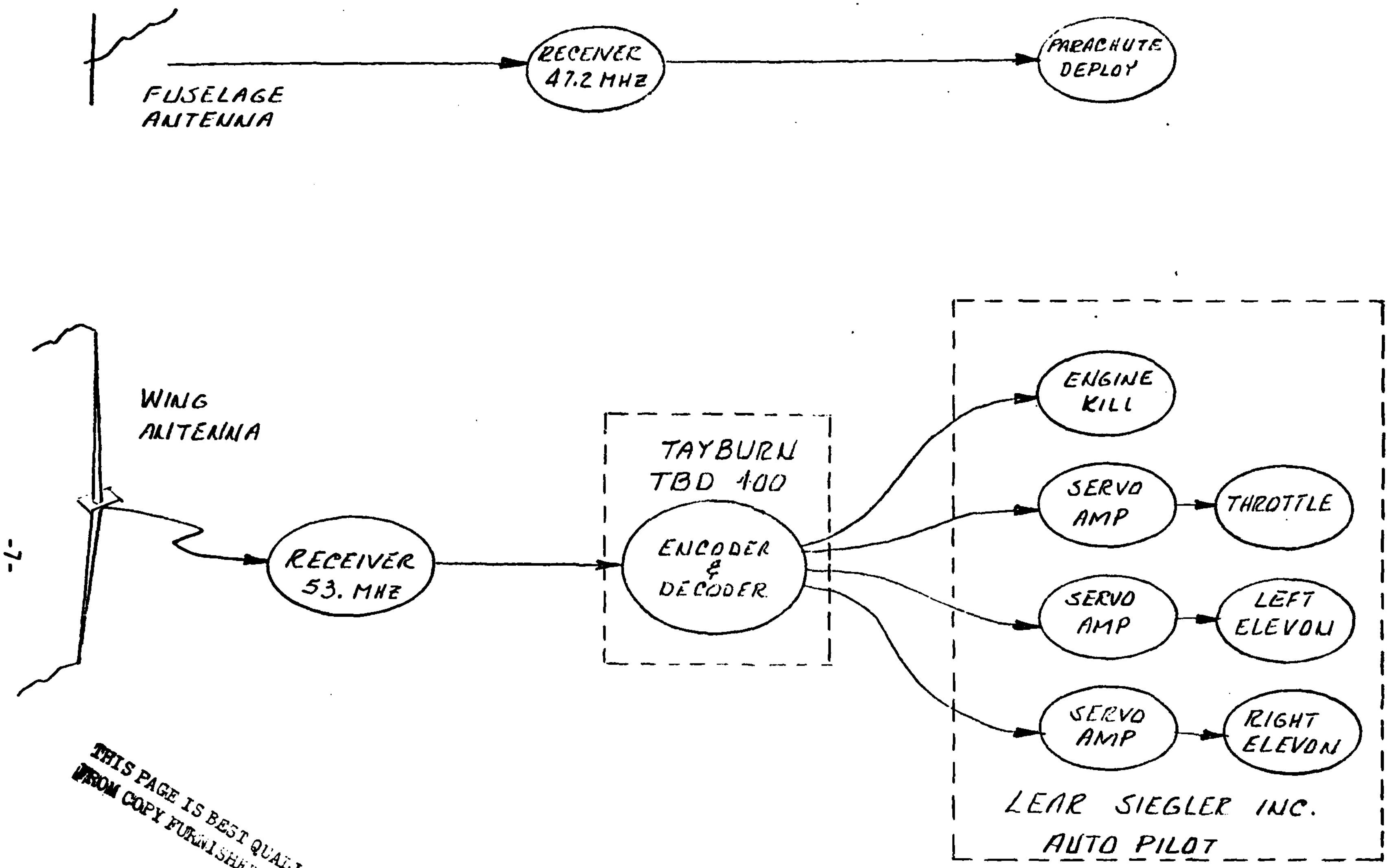


FIGURE 6 AIRBORNE COMMAND LINK

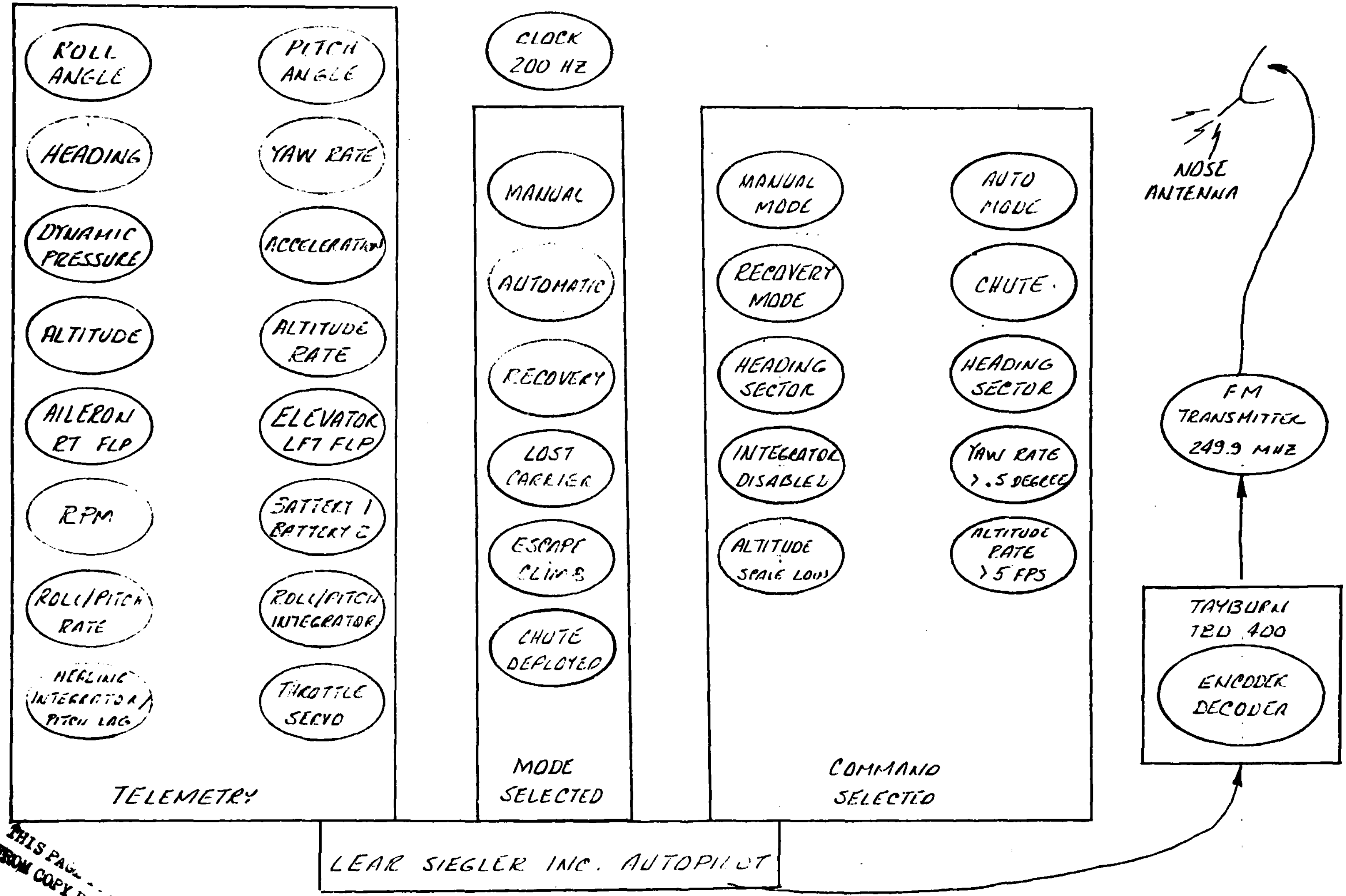


FIGURE 7 AIRBORNE TELEMETRY

on video cassette, for review after recovery, as well as displayed on the pilots control console.

Terminal guidance for automatic recovery is depicted in Figure 8. The aircraft carries a transmitter which is guided by a ground receiver on a pre-determined glide slope within predetermined azimuth limits. Error signals from the receiver are transmitted to the D.S.I. intergrator, modified and sent back to the aircraft as a command to correct the deviation and get back onto the glide slope. Figure 9 describes the terminal guidance loop.

A pre flight flight plan is shown in Figure 10. The aircraft flies a right pattern approximately 1 mile wide and 3 miles long. As the aircraft approaches the azimuth zero line, and below the vertical intercept line, the automatic recovery mode is selected, the aircraft holds azimuth until, a lock on occurs at the moment the aircraft crosses the azimuth zero line and the autopilot takes over and provides corrective commands to return to the zero line. The automatic recovery mode also calls for an altitude hold until the aircraft intercepts the glide slope at which time altitude hold is disengaged and the aircraft rides the beam on the glide slope. A spotter was positioned approximately 3500 Ft. down wind of the recovery area to provide range data necessary for gain changes in the D.S.I. intergrator.

3. OPERATIONAL MODES

3.1 Manual Mode

Selection of manual mode operations permits the pilot to fly the aircraft using information displayed on the pilots console and on the television screen. The aircraft will respond to control stick movements by the pilot. This mode uses the stability loops of the L.S.I. autopilot, so that the aircraft holds altitude and azimuth when the pilot gives no stick commands.

3.2 Automatic Mode

Selection of automatic mode operations permit the pilot to select a heading, and altitude and an airspeed, command the aircraft to hold at the selected parameters and the aircraft will maintain those parameters until the parameters are modified.

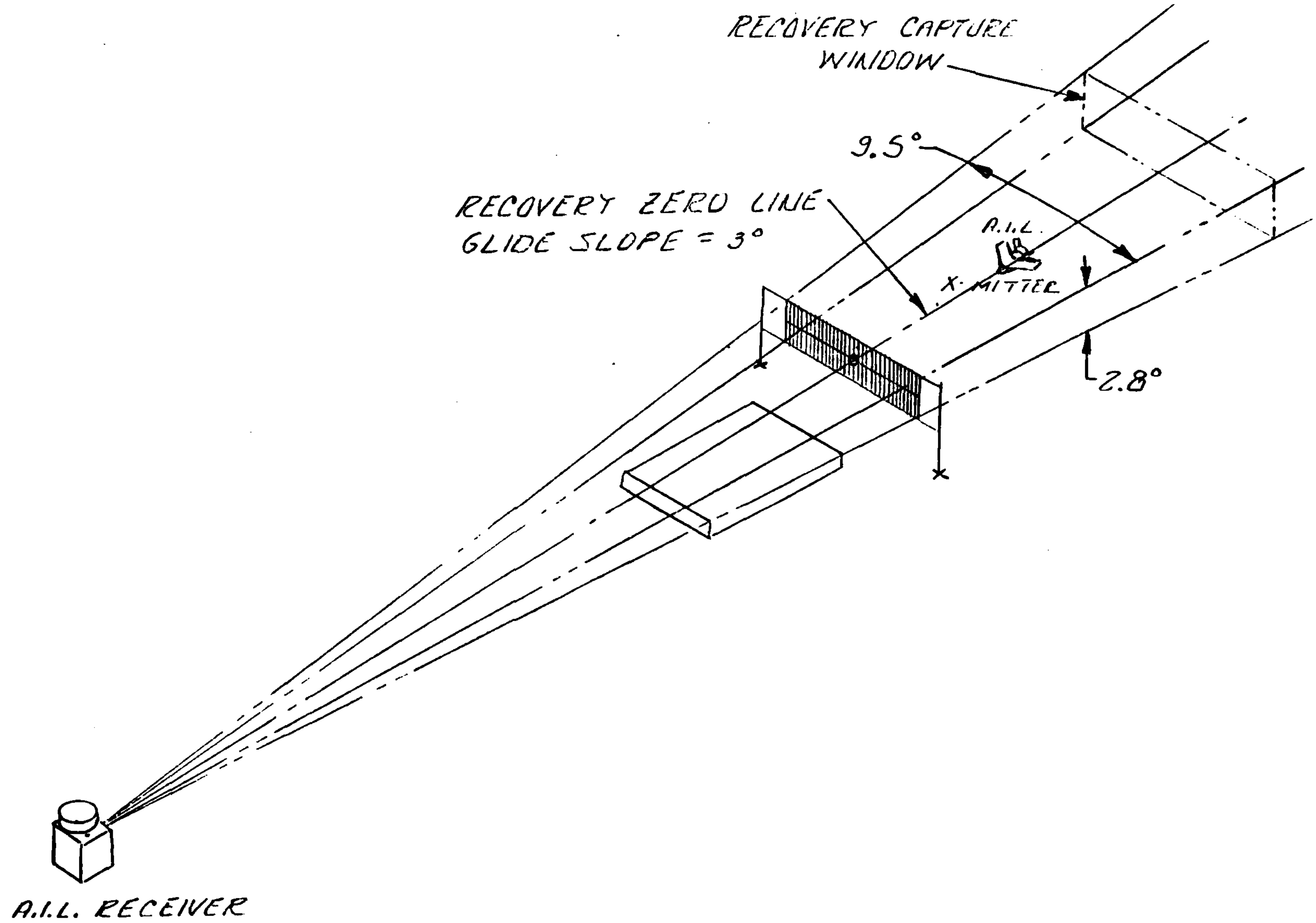


FIGURE 8 TERMINAL GUIDANCE PATH

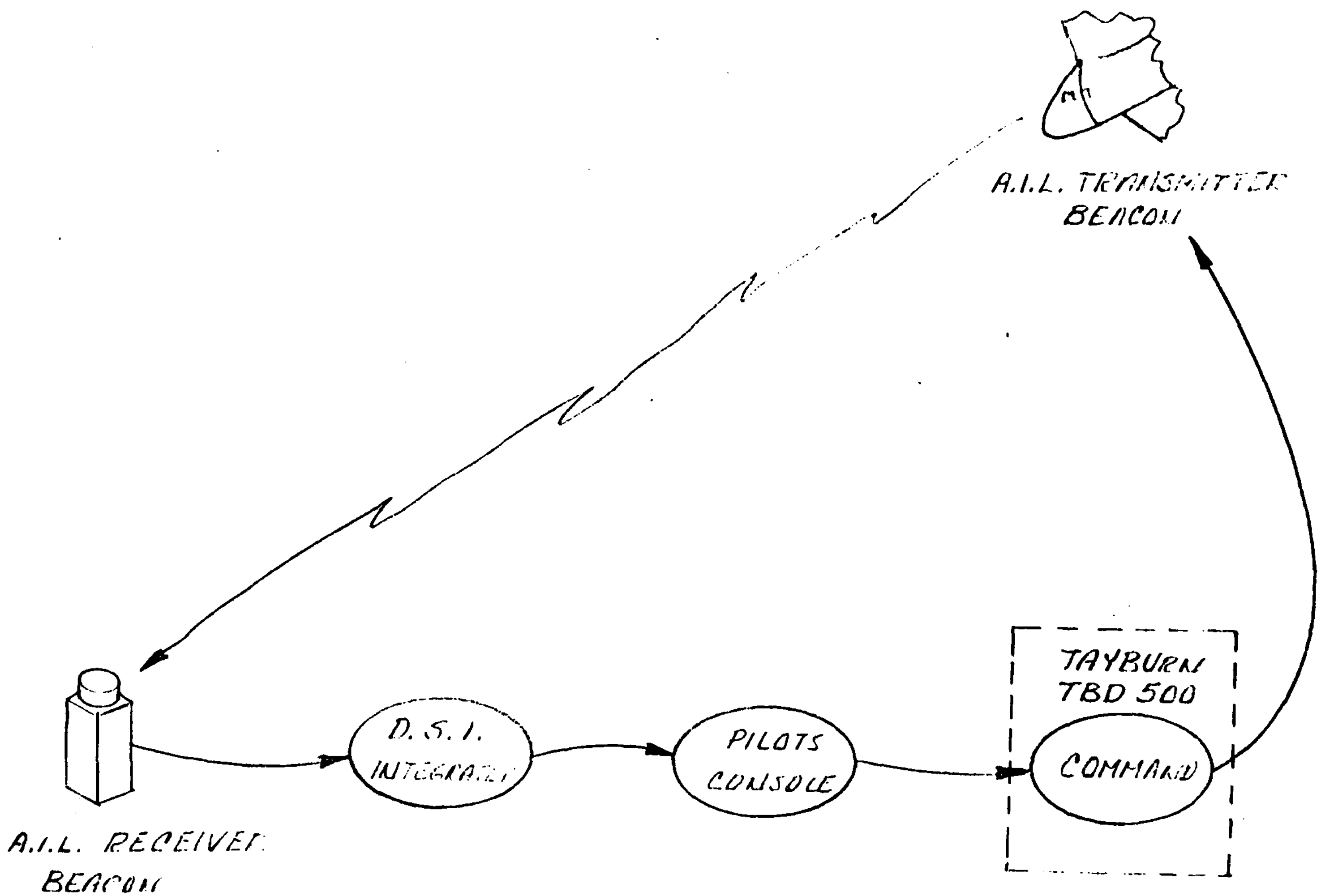


FIGURE 9 TERMINAL GUIDANCE LOOP

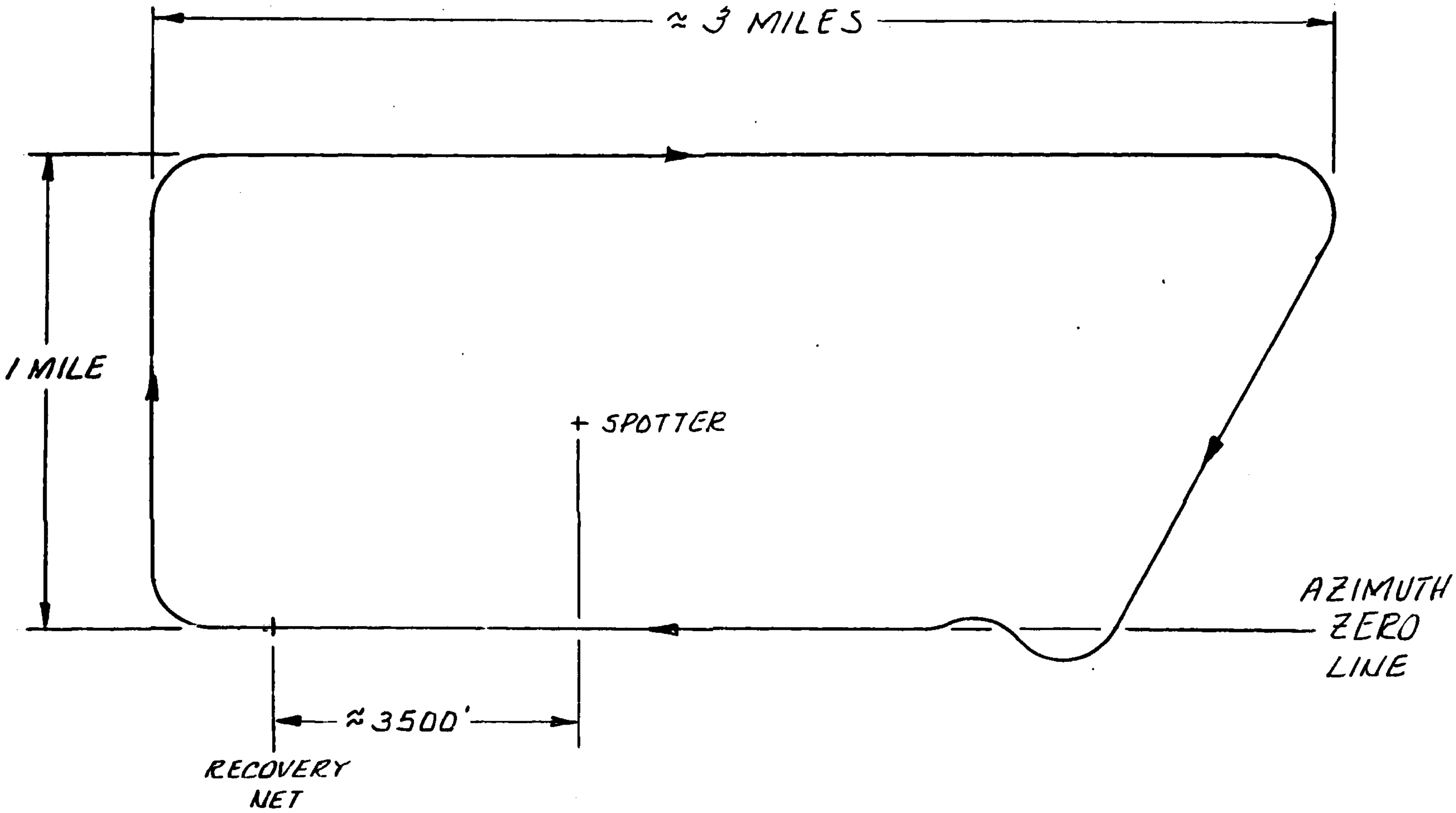


FIGURE 10 FLIGHT PATTERN

3.3 Recovery Mode

Selection of the recovery mode permits the A.I.L. recovery equipment to fly the aircraft through the autopilot. The aircraft will hold the last command, unless a change is transmitted to it. As the aircraft crosses the azimuth centerline an error signal from the A.I.L. receiver is transmitted through the ground console to the autopilot. Corrections are updated to maintain heading until the elevation centerline is crossed. The error signal now maintain's the aircraft on the correct glide slope to intercept the center of the recovery net.

3.4 Escape Climb Mode

Selection of this mode is done automatically by the autopilot whenever loss of command signal occurs. It works in connection with the TBD 400 aboard the aircraft. The autopilot puts the aircraft in a wide right hand circling climb. This is to allow the aircraft time to fly above possible ground clutter to relock on the command signal or to gain enough altitude to activate the emergency parachute system.

4. TEST FLIGHTS

The flight tests were conducted over an eight week period. Most of the initial time was spent in improving the RF link for greater range. Problems were also encountered in the A.I.L. recovery equipment when it was field tested. In addition D.S.I. / L.S.I. were checking out the improved two axis flight control system.

Before each flight an A.I.L. beacon was placed at the center of the net and the receiver was physically centered to give zero error signals.

The aircraft was modified from data taken from wind tunnel tests of the R4-D aircraft. During the first flight this modification and a heavy magnetic compass in one wing tip resulted in a dutch-roll problem. The parachute was used and the aircraft had only minor shroud damage. All electronics were in working order after landing. Minor modifications were made and the aircraft was flown again.

Due to adverse weather (rain & snow) and gusty crosswinds an automatic recovery proved very difficult. A manual recovery was made for the first seven flights. Although the aircraft would lock on the recovery glide slope a number of times during most of the flights it would either veer to one side or begin to oscillate, because of the side winds.

The gains between the A.I.L. and the autopilot were adjusted and another flight would follow. D.S.I. put over four (4) hours of flight time on the SKY-EYE RPV.

D.S.I. perfected a method of recording the telemetry data through the Tayburn unit onto the video cassette. This provided valuable training technique for the ground pilot who could review the video picture. The control console repeated its functions as if during an actual flight.

With help from L.S.I. on simulating the landing modes and changes in their autopilot recovery mode function's, a successful automatic recovery was made. Another try was attempted the next day, but because of intermittent telemetry data the aircraft was recovered manually. Because of schedule, funding, and of equipment problems, further testing was discontinued.

5. CONCLUSION

The autopilot designed and built by L.S.I. flies the aircraft smoothly. Level flight, fixed on a heading could be maintained during weather conditions that caused light manned aircraft great difficulty. The emergency parachute recovery system worked when necessary, and resulted in minimal aircraft structual damage and no electronic damage.

The A.I.L. recovery system did perform as designed, but the dynamic coupling between the aircraft, autopilot, ground error signal, and interface box proved to be a major problem, that was finally overcome. The automatic recovery design and concept was proven during this program. Further work is recommended in order to make it an operational system.